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OPERATION AND MAINTENANCE OF IRRIGATION SYSTEMS

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OPERATION AND MAINTENANCE OF IRRIGATION SYSTEMS

Floyd M. Roush[1]

SYNOPSIS

There is a tendency quite often among water-user organizations to neglect or defer maintenance on irrigation facilities. This paper points out that the key to a successful irrigation enterprise is keeping all maintenance work current. Further, other factors essential for good operation are an organization of qualified personnel, maintaining good public relations with the water users, selection and maintenance of equipment, adequate maintenance and replacements, conserving the water supply, and protecting the irrigated land from seepage.

We are assembled today in the cradle of modern irrigation. One hundred and seven years ago irrigation in America was begun in this very city. The design and construction of the first ditch from City Creek by the Mormon pioneers was a simple one. While history does not dwell on this point, we can be certain that the operation and maintenance problems were also simple.

The successes here gained, the failures here experienced are the foundation upon which knowledge of irrigation operation and maintenance was built throughout the West. In those days labor was cheap, horsepower plentiful, and the principal equipment required consisted of shovels, scrapers, a plow, and a good strong back. Even as late as the 1920's most of the ditch cleaning and repairing was performed with slips and fresnos powered by horses. Draglines then were large and cumbersome requiring considerable time to move, and caterpillar-type tractors with scrapers were almost unknown. A few of the larger projects had Ruth dredgers which performed well, but they, too, were slow and cumbersome.

Today the picture is different—in a period of high labor costs, mechanization is a must. Many pieces of maintenance equipment have been developed and are on the open market. The trend is toward more mobile equipment which can be easily transported or has its own power of locomotion.

The history of irrigation is replete with examples of the folly of neglecting maintenance. The best irrigation system ever constructed will eventually fail if it is poorly operated and the maintenance is neglected. Keeping maintenance work current on all facilities is the keystone to a successful irrigation enterprise. Many water user boards of directors often pare maintenance funds to the bone in their desire to operate as cheaply as possible. This results in inadequate and faulty maintenance. Deferred maintenance usually costs far more in the long run than keeping the system in top operating efficiency at all times.

The objectives of an operating force in the operation and maintenance of an irrigation project should be to:

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1) Provide equitable apportionment of water among the users and in quantities sufficient to satisfy crop requirements.
2) Keep the irrigation system in top operating efficiency at all times through proper maintenance.
3) Obtain the longest life and greatest use of the facilities by providing adequate maintenance and replacements.
4) Conserve the water supply, and
5) Preserve the irrigated lands.

The task of an operating force is to achieve these objectives at the lowest possible cost to the water users, as irrigation at its best, is a high overhead-cost type of agriculture.

In meeting objective Number One, that of equitably apportioning the water among the users, there are a number of factors which must be considered. Organization, personnel, good water records, well-functioning measuring devices, method of delivery, and a satisfactory system of communications are all important factors in obtaining an equitable distribution of the water supply, which is essential if harmony is to be maintained among the water users.

The type of organization governing the operation and maintenance of irrigation works varies considerably, and the one chosen to carry out the functions is often determined by State laws. Whether the organization be an irrigation district; water users associaton (mutual company); water, canal, ditch or reservioir company; a reclamation or conservancy district, they are controlled by a Board of Directors or Commissioners. Financing is accomplished by a toll charge or an assessment which can be collected by the County Treasurer, or a rate is established for the sale or rental of water by volume.

The Board of the governing body usually hires a Manager who is responsible for selecting the personnel required for operating the project or system. The number of personnel and type of positions under the Manager depend on the size of the irrigation project. On larger projects in the Missouri River Basin area, in addition to the Manager, other personnel may consist of an Assistant Manager, Superintendent of Irrigation, dam superintendent or damtender at reservioirs, gate-tenders at diversion dams, watermasters, ditchriders, maintenance foreman, machine operators, clerks, laborers, etc.

The ditchrider, as a rule, holds the key to maintaining a good relationship between the water user and the management. He is the man having immediate contact with the water users and, having ability, tact and fairness, can maintain good public relations. He is responsible for the delivery of water. The size of a ditchrider's ride or beat is dependent upon the compactness of the irrigated area. Ordinarily, he can serve an area of 4,000 - 5,000 acres of irrigable land, cover a ride of 50 - 60 miles of ditch a day with 50 to 60 turnouts. The ditchrider usually works on maintenance during the non-irrigation season, although some ditchriders prefer other work during this season. While superintendent of an irrigation district in the North Platte Project, I had a working agreement with the local sugar factory whereby the factory would employ all of the ditchriders I would release. This gave employment to riders while the ditches were drying and provided dependable labor each year for factory operation, which is seasonable in its operation.

The watermaster is responsible to the Manager for the operation and maintenance of a division of a project. He will be in charge of a number of ditchriders and a maintenance crew. Geographic barriers or location of lateral systems usually determine the size of a watermaster district. These districts generally cover 25,000 - 30,000 acres of irrigated land, depending somewhat on the compactness of the area served.

Good water records are essential for smooth operation and in providing an equitable distribution of water to the users. Forms and records must be tailored for each individual project or system. Forms are needed for day-to-day operations in controlling the water in the right amounts throughout a system, and in holding operational wastes to a minimum. Good operations should keep spillway or operational wastes below 5 percent for the season. Long-time records are needed to determine the carriage losses on the integral parts of a system. These losses must be known to obtain better daily operations. Good water records will also provide data on the location of water losses and seepage, and are essential if and when a corrective program should be initiated.

Properly functioning measuring devices are necessary in determining water diversions, canal and lateral losses, and delivery of water to the farms. These may be rating stations, rating flumes, wiers, orifices, Parshall flumes, or other types, depending on the accuracy required or the head available. The Sparling meter is one of the more recent developments which is gaining in popularity as a measuring device. This meter has a rotating vane and a dial which registers the quantity of water delivered.

A dependable communications system is a must on larger projects for the control and delivery of water. A three-way radio system has proven, from my experience, to be cheaper in operation and more dependable than a telephone system in our area. Fixed stations properly located throughout a project will provide contact with all operating and maintenance personnel having units in their cars or trucks.

There are several methods of making water deliveries to farms under an irrigation system, such as demand, rotation, continuous flow' and restricted or modified demand. Under the demand method, water users are delivered water in quantities as requested. This is the most ideal method from the standpoint of the water user, but requires a system of larger capacity than some of the other methods in meeting peak demands for irrigation water. Under the rotation method, the water user receives water for definite periods of time and is without water during the intermediate periods. Rotations may be made between two users, two or more groups of users under a single lateral, two or more laterals or two or more divisions of a project lateral system. The rotation method is especially advantageous for small farms as it permits the user to receive larger heads, thereby completing his irrigation in shorter periods and with less water. Under the method of continuous flow the water user receives an allotted amount of water as a constant flow throughout the irrigation season. This system is wasteful of water, as the operator is required to take water at times when he has no need for it. Under the modified demand method, the water user may have water delivered to his farm in quantities as requested, except during periods of peak demand when he is restricted to the quantity of water or size of irrigation head he may receive. The available capacity of the system is apportioned to the irrigated land. This method works to a disadvantage for the small farms.

Objective Number Two, that of keeping the irrigation system in top operating efficiency at all times, should head the list because an improperly maintained project is bound to give poor service. Inadequate maintenance on portions of a system can throw the entire system out of balance to the extent that water deliveries will be in jeopardy and operating costs increased. Neglected maintenance usually costs far more in the long run, and the old axiom "a stitch in time saves nine" is one that certainly holds true when applied to irrigation works.

Canals and laterals should not be operated with the water surface higher than the designed normal water surface elevation. Crowding irrigation ditches beyond their normal carrying capacity tends to encourage seepage. Ditches should be maintained free of silt berms and other obstructions. Overcleaning should be avoided as it removes the silt layer covering the wetted perimeter and often results in excessive seepage.

Bank erosion and sloughing, if uncontrolled, increases maintenance costs since the eroded material must be removed as it collects in the channel downstream. Uncontrolled bank erosion also enhances the chances for canal breaks and increased seepage losses. Canal banks should be stabilized by some form of riprap, preferably rock, or a coarse gravel containing a binder of sand and soil.

Heavy growths of vegetation along canal banks should be controlled as a part of the annual maintenance program. Uncontrolled growths of weeds can increase water losses, infest irrigated lands with weeds from seed dropping into the water, and in general are a hindrance to an efficient and economical operation. Also, heavy growths of weeds on ditch banks harbor burrowing animals and provide a breeding ground for grasshoppers and other pests detrimental to crops.

Ditch bank weeds can be controlled quite successfully by seeding the banks to grasses. Spraying the banks with 2,4-D following the seeding will control the weeds until the grass cover is established. Once the cover is well-established, controlled grazing may be permitted. The ditchbanks of the Mirage Flats Project in northwestern Nebraska were seeded with brome, crested-wheat and western-wheat grasses. The irrigation district controls the grazing on the banks and these seedings are providing some excellent pasture for livestock, in addition to controlling weeds. This practice has been extended to other projects being constructed by the Bureau of Reclamation. The seeding is often made a part of the prime contract for canal and lateral construction.

Large trees, if permitted to grow on ditchbanks, offer a serious hazard. They can cause a bad break, if uprooted during a wind storm. Willows can soon encroach upon the cross-section of a ditch and limits its capacity. They can be controlled quite easily, however, by spraying with 2,4-D during the month of August. Kills of 90 percent to 100 percent are often obtained with one spraying.

Excessive growths of water weeds can cause high water losses through seepage, evaporation and overflowing of the banks. They also reduce velocities causing the water to drop its silt load, thereby increasing the cost of cleaning. Water weeds can be controlled by drying the ditch for short periods, by chemical treatment with naphtha compounds or mechanical means such as chaining, dragging, etc. It has been found that dragging heavy chains along the canal perimeter not only loosens the moss and water weeds but under faborable conditions has been known to tighten the canal and reduce seepage losses.

Moss growing in concrete lined canals will increase the coefficient of roughness to such an extent that the carrying capacity can be radically reduced. Considerable difficulty has been experienced with moss growing in the concrete lined canals of the Colorado-Big Thompson Project in Colorado. On this project, the water either enters a reservoir or river before being used for power development or irrigation use. Since these reservoirs and rivers are stocked with trout, strong chemicals cannot be used which will harm fish life. The problem has been solved by injecting a copper sulphate solution into

the water in the canals, so that it will be carrying two parts per million by volume. The injection should continue for a period of 30 to 35 minutes to obtain a good kill. Good results have been obtained with concentrations as low as 1.5 parts per million.

Regular inspections should be made of all structures at the close of each irrigation season for determining needed repairs. They should be inspected again before turning the water back into the canals. Repair of concrete structures should be made in strict accordance with approved methods. All concrete of questionable quality should be removed. Repairing faulty concrete is like fixing a decaying tooth—it is better to remove too much than too little as affected concrete generally continues to disintegrate, just as a rotting tooth will.

All wooden and some metal parts subjected to deterioration from water and the elements should be painted regularly. Gate hoists and other moving parts should be properly oiled. Graphite should be used where moving parts are subjected to blowing and grit.

Cleaning, scraping, sand-blasting and painting trash racks and other metal parts submerged in water is usually a very expensive item of maintenance, because of the time required and high cost for labor. Unless painting is required for the sake of appearance, it is sometimes found to be more economical to replace these parts when rendered useless by rust and corrosion than to extend their useful life by regular painting. This is quite true for heavy trash racks on dams which require considerable labor and expense to remove, in addition to the cost of cleaning and painting. For example, the trash racks at the Guernsey Dam in Wyoming were removed and painted in 1952. It was found that only about 25% of the metal bars had rusted away on some sections which were subjected to severe erosion. Indications were that trashracks may have life of at least 75 - 100 years without painting; therefore, replacement of sections as they rust out will be much more economical than painting them at regular intervals.

Present practice in our area is to use a vinyl-resin paint on gates and metal structures subjected to alternate atmospheric and submerged exposure. Coal-tar emulsions have resistance to ultra-violet light and usually perform well on metal that remains out of water for considerable periods of time.

Well-painted and well-kept ditchrider and maintenance-labor houses not only lengthen the life of the buildings, but provide an inducement in securing and retaining better help. All other buildings should be painted to lengthen their life of service.

A cover or light bulkhead placed on concrete siphons, which are drained, will minimize cracking caused by contraction from cold air drafts occurring through the barrel or barrels during winter months. Lined tunnels can be protected from the elements by swinging doors on the portals.

Since measuring devices are the key to obtaining records of diversions, losses, farm deliveries and other flow data, it is important that they function properly at all times and accordingly should be adequately maintained. Weir pools should be kept clean, weir crests repaired and submergence prevented. The water users are responsible for the greater part of weir submergence in their attempt to raise the head lateral to take in more land or failure to keep the lateral clean. Submergence can usually be eliminated by requiring the head ditch to be cleaned or lowered before water will be delivered. Submerged weirs may often be replaced by measuring devices requiring less loss of head such as Parshall flumes or submerged orifices which require submergence to operate properly.

The third objective, that of obtaining the longest life and greatest use of irrigation facilities, can best be accomplished by providing good maintenance and a program of systematic improvements and replacements. In many instances, it is hard to determine the point at which good maintenance ends and replacement begins. Good maintenance, for example, may necessitate the replacement of a gate leaf, later a gate stem and perhaps still later the lifting device. As irrigation works advance in age, a program of replacing worn-out and obsolete structures is essential in extending the useful life of an irrigation system. Improvements or betterments such as additional control structures and canal linings will provide for better service, reduce seepage and extend the period of their usefulness.

Water supply is rapidly becoming the limiting factor in the development of new irrigated lands and it is not in abundance on many of the older projects. Therefore, the conservation of the water supply as a fourth objective becomes quite important. President Eisenhower in a recent speech before the annual meeting of the National Rivers and Harbors Congress summarized the situation with these words, "I have become convinced that before long, America will almost unanimously look upon water as its single greatest resource." Thus the President pointed up the fact that we have reached the milestone in our development whereby we no longer can be careless and slipshod in the use of our water resource. To conserve water it becomes imperative that losses and wastes be reduced or held to a minimum. The principal losses and wastes on an irrigation system are: (1) Carriage losses, (2) Operational wastes, and (3) farm wastes and deep percolation losses.

Carriage losses can be reduced by: (a) keeping the canal and lateral systems clean and efficient; (b) avoiding overcleaning of ditches which removes the naturally deposited silt layer or lining covering the canal perimeter; (c) never overloading the irrigation system beyond its designed capacity; and (d) by lining canals and laterals, particularly where losses are high.

Operational wastes can be reduced by: (a) an alert and efficient operating organization trained to hold wastes to a minimum; (b) requiring advance notice from water users for shutting off water; and (c) providing storage or regulatory facilities, if possible, within the system.

Operating personnel can control to some extent the farm wastes and deep percolation losses which occur on the farm itself by: (a) watching for excessive waste water from the farms and having the power to regulate the water users' headgates until they can take care of their irrigation water; (b) improving irrigation methods and practices—these are available through the County Agricultural Agent, Soil Conservation Service, and other agencies, and should be encouraged by the Irrigation District; (c) setting up water allotments each year and charging for additional water used above the allotment; and (d) selling water to the users by the acre-foot or volume as electric energy, gas and other utilities are sold, in lieu of a straight per-acre charge.

There is a relationship between maintenance costs and the quantity of water carried through a system. While this cost is not directly in proportion to the quantity of water carried, the cost, nevertheless, is there, because as more water is carried through a system, more silt is deposited which must be removed. Further, more erosion, wear and tear occurs to the system and its appurtenant structures. Reduce the losses and wastes and operation and maintenance cost will likewise be reduced.

The last objective, that of preserving the land, is an important one. Irrigable lands lost through seepage or other means results in a loss in crop production and lowers the capacity of the farm owners to pay operation and

maintenance costs, taxes, and construction costs. Irrigated lands can be conserved by correcting faulty irrigation or operation practices, the cause of which may be: (a) excessive use of irrigation water, (b) high seepage losses from canals and laterals, (c) poorly located or constructed drainage systems, and (d) poorly maintained drainage systems.

The excessive use of irrigation water may be corrected by an extensive educational program. The County Agricultural Agent and the Soil Conservation Service should be prevailed upon to provide assistance in this type of program. High seepage losses can be reduced by lining the ditches where seepage is the heaviest and by carrying out other practices outlined under the fourth objective. In addition to concrete linings, excellent results are being obtained from heavy compacted earth linings and buried asphaltic membrane linings. In most instances these are lower in cost than the concrete linings, but do not offer the stability provided by concrete.

Drainage ditches, like canals and laterals, must be maintained if they are to function properly. It is fundamentally as important that the drainage system be equally as effective as the irrigation system. There is a great tendency among water user organizations to neglect the drainage systems, since they are more or less self-operating and deterioration is generally slow. There is a feeling on the part of many water users that it is much more important to get the water to the land than providing a means for taking care of seepage and waste water. They are not alarmed until the water tables build up to the point where the land's crop producing capacity is affected.

Open drains are inducive to producing heavy growths of cattails, willows and other water-loving plants. This type of vegetation impedes the flow of drain water and silt being carried in suspension is dropped, thereby gradually filling the drain with sediment. Most of the sediment enters the drainage systems with waste water from the farms. Inlet structures should be provided at points along the drains to prevent gullies forming where waste water enters a drain.

Maintenance of drains in many respects is somewhat similar to that required on irrigation ditches. Some projects have found it pays to keep a man with a shovel continually working on the drains. Shovel work in keeping the channels straight and the water confined to small channels within a drain will carry silt through it, thereby minimizing cleaning costs with heavy equipment. Some projects keep the drains open and the water confined to a small channel by pulling ditchers or other implements through them.

On many projects, the shift from open ditches to underground pipe lines for irrigation and drainage use has been taking place at an ever-increasing rate. The reason is evident; maintenance costs are reduced and efficient use can be made of the land normally occupied by an open ditch. Also, equipment use is made much easier on the farms and unsightly, weedy ditch banks are eliminated.

The selection of suitable operation and maintenance equipment is extremely important to an operating organization. Good equipment is expensive; therefore, careful study and thought should be given to its purchase so it will satisfactorily perform the work for which it is intended. Consideration should be given to the purchase of mobile equipment for use in cases of an emergency, such as canal breaks. Irrigation projects cannot afford to have expensive equipment sitting around idle a large portion of the time. For this reason I have found it to be much cheaper to rent equipment of this type when needed. Equipment should be well-maintained and in good operating condition at all times, so as to be able to meet emergencies requiring its imme-

diate use.

In conclusion, it can be stated that the following factors are essential in the operation and maintenance of an irrigation project or system:

1) Have an efficient organization of qualified personnel.
2) Keep the irrigation system in high operating efficiency at all times by adequate maintenance.
3) Maintain good public relations and equitably apportion the water supply among the users.
4) Provide adequate maintenance and replacements for extending the life and usefulness of the facilities.
5) Inspect the system regularly to provide data for establishing maintenance and replacement programs.
6) Conserve the water supply by reducing losses and wastes.
7) Protect the land by careful use of water and maintenance of a good drainage system.
8) Select carefully the necessary equipment for operation and maintenance work and keep that equipment in good operating condition at all times.

PROCEEDINGS-SEPARATES

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c. Discussion of several papers, grouped by Divisions.
d. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.
e. Presented at the Atlantic City (N.J.) Convention in June, 1954.

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